

# **Ice Jam Mitigation Part 2: Emergency Response**

**Kathleen D. White, PhD, PE  
Research Hydraulic Engineer  
Associate Technical Director**

**USA Army Corps of Engineers Engineer Research and Development Center  
Cold Regions Research and Engineering Laboratory  
Hanover, NH 03755-1290**

**[Kathleen.D.White@erdc.usace.army.mil](mailto:Kathleen.D.White@erdc.usace.army.mil)**

# Ice Jam Mitigation

- Disaster Preparedness
- Emergency Measures
- Post-Flood Activities
- Permanent Measures
  - Freezeup Jam Control
    - Control production and transport of frazil ice
    - Displace jam initiation location
  - Breakup Jam Control
    - Control timing of ice breakup
    - Displace jam location

# Mitigation Goals

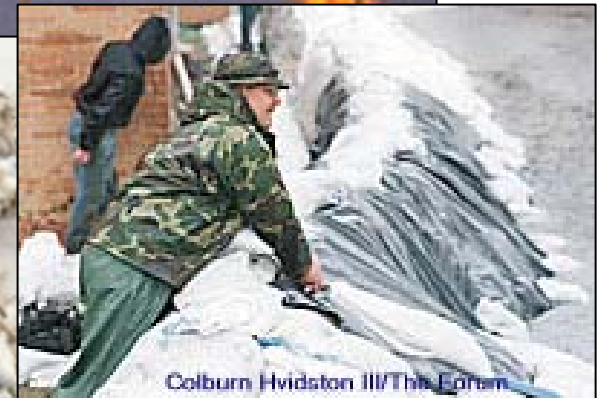
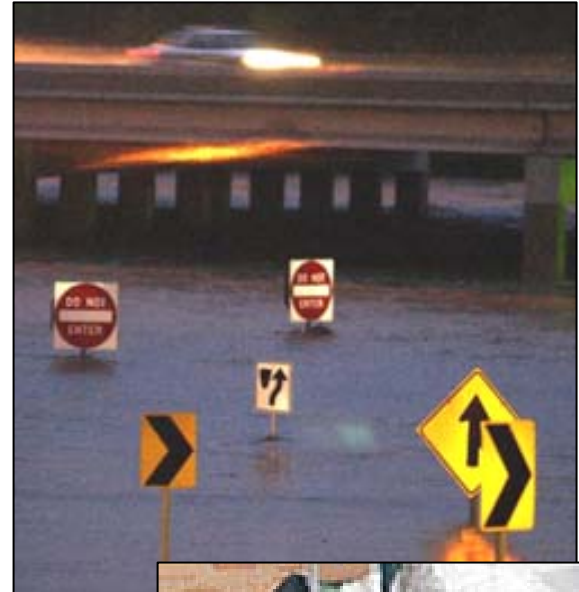
- Disaster Preparedness
  - Awareness of threat
  - Flood protection
  - Reduce ice supply
  - Control breakup sequence
  - Increase conveyance
- Emergency Measures
  - Flood Protection
  - Increase Conveyance
  - Remove Ice
  - Avoid evacuations in unsafe conditions!

- Permanent Measures
  - Flood protection
  - Reduce ice supply
  - Increase conveyance
  - Control breakup sequence
  - Displace ice jam location



# Disaster Preparedness

- Non-structural intervention
- Weeks to several months lead time
- Can be inexpensive
- Effective?
- Includes
  - Mitigation plan: in many states, mitigation plan must be in place prior to taking actions that will dislodge ice jam
  - Monitoring
    - Observations to identify problem areas early
  - Early warning
    - Alert system
  - Ice weakening/thinning
  - Equipment placement
  - Supplies:
    - Source of unfrozen sand
    - Sandbags
    - Jersey barriers
    - Polyethylene sheeting



# Monitoring

- Visual
- NWS/USGS sources via web
- What are the present ice conditions?
- How does the ice cover form?
  - Thermally grown?
    - Estimate ice thickness from AFDD
  - Is there likely to be deposition?
    - If so, where?
    - Increase coefficient used to estimate thickness
- What ice conditions might affect future mitigation measures?
- What is the forecast?

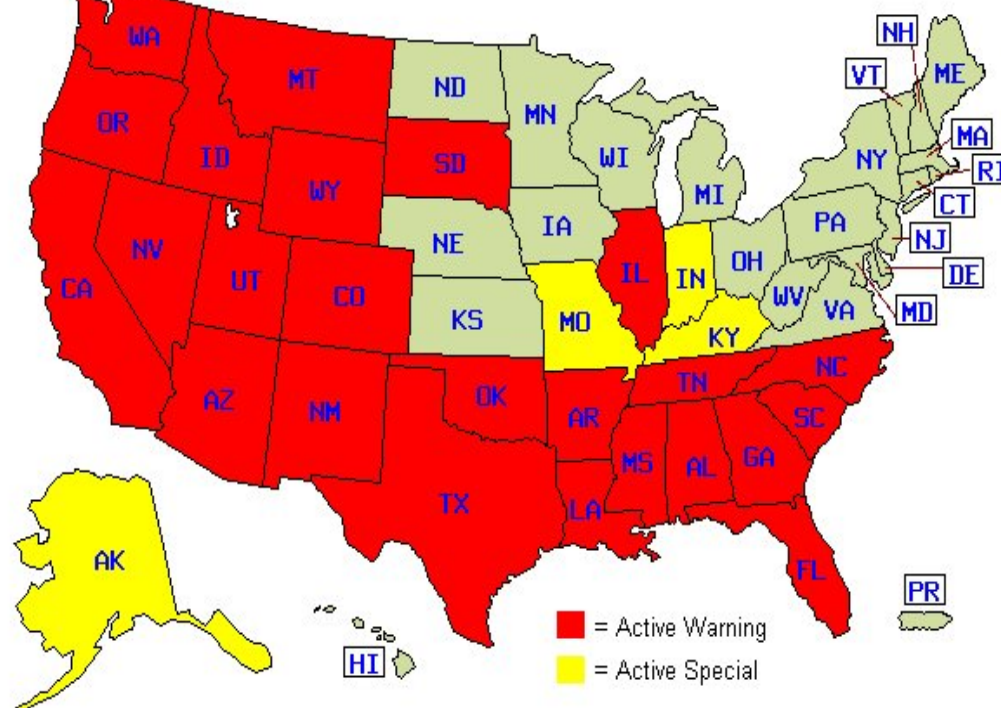


<http://waterdata.usgs.gov/mt/nwis/rt>

## Interactive Weather Information Network ----By the National Weather Service

**\*\*NEW\*\*-- Major Storm? BUSY? SLOW? ALTERNATE LINKS ->Click here -> Live Weather and Warning data streams over Internet!-- FASTER DOWNLOADS of live Weather Warnings HERE!.**

Updated: Wed Feb 10 16:50:49 1999 GMT



This page will reload itself every 60 seconds to keep you up to date.

[Back to Main](#)



# National Weather Service Forecast Office

## Glasgow, MT

HOME NEWS ORGANIZATION

SEARCH  Go

Local forecast by city and state



### River Ice Information for Eastern Montana

[Submit a River Ice Report](#) (requires username and password).

[Table of conditions for area rivers.](#)

[View individual reports.](#)

[View recent images of the rivers in eastern montana.](#)

[River Ice Guide and Glossary \(with pictures\)](#)

reference email : [andrew.pohl@noaa.gov](mailto:andrew.pohl@noaa.gov)

[Webmaster](#) [Disclaimer](#) [Privacy Policy](#) [Product Descriptions](#)

National Weather Service  
Glasgow Weather Forecast Office  
101 Airport Road  
Glasgow, Montana 59230

Tel: (406) 228-4042

Last Update: July 10, 2003

- Go
- Current Hazards
  - NE Montana
- Current Conditions
  - Observations
  - Radar Images
  - Satellite Images
  - Rivers & Lakes
  - AHPS
  - Ice Conditions
  - Cameras
  - Road Reports
- Forecasts
  - NE Montana
  - Aviation
  - Fire Weather
  - Digital Prototype
  - National Graphic
  - Local Forecasts
  - Hydrology
  - Extended Outlooks
  - Met. Data
- Climate
  - NE Montana
  - WRCC
- Outreach
  - Weather Radio
  - Spotters
- Topics
  - Severe
  - Science
  - Calculator
  - Links
- Weather Safety
  - Storm Ready
  - Lightning
  - Flood Safety
- Other
  - Press Releases
  - About Us
  - FAQs
  - Contact Us



**National Weather Service Forecast Office**

# Glasgow, MT

[www.nws.noaa.gov](http://www.nws.noaa.gov)

HOME NEWS ORGANIZATION

**River Ice Summary Table**

| River                      | Location          |
|----------------------------|-------------------|
| Click to see entire report |                   |
| <a href="#">Milk</a>       | Highway 24 Bridge |

[Webmaster](#)

National Weather Service  
Glasgow Weather Forecast Office  
101 Airport Road  
Glasgow, Montana 59230

Tel: (406) 228-4042

Last Update: July 10, 2003

[Disclaimer](#) [Privacy Policy](#) [Product D](#)

## NWS Glasgow - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media

Address http://www.wrh.noaa.gov/Glasgow/rivers/Milk/Milk.2004 Go Links Customize Links RealPlayer Windows Media Windows Best of the Web Channel Guide



**National Weather Service Forecast Office**

# Glasgow, MT

[www.nws.noaa.gov](http://www.nws.noaa.gov)

HOME NEWS ORGANIZATION

SEARCH Enter Search Here Go

**Site Information**

River: *Milk* Date: 01/21/2004  
County: Valley Time: 1600  
Location: Highway 24 Bridge

**River Conditions**

Air Temperature (F): 3 Stage (ft): 2.2  
Water Temperature (F): Flow (cfs):  
Ice thickness (in): 18 Snow Depth on Ice (in):  
The river is: Ice covered for unlim miles upstream  
The river is: Ice Covered for unlim miles downstream  
Percentage of channel cover by ice is: 100

**Freeze-Up**

Type of ice present: Sheet\_Ice

**Intact and Breaking Ice Cover**

Is there fracturing along the banks? No  
Cracks in the ice cover? None  
Water on top of ice? None  
Evidence of decay? Snow\_covered

**Ice Jams**

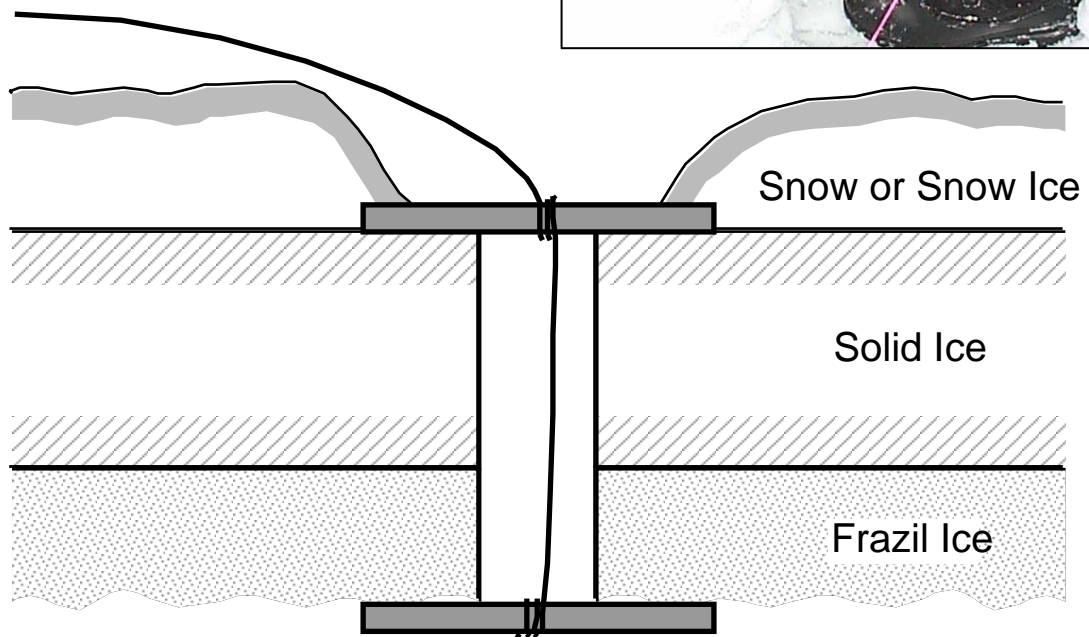
Ice Jam Type: None  
Ice Jam Obstruction:

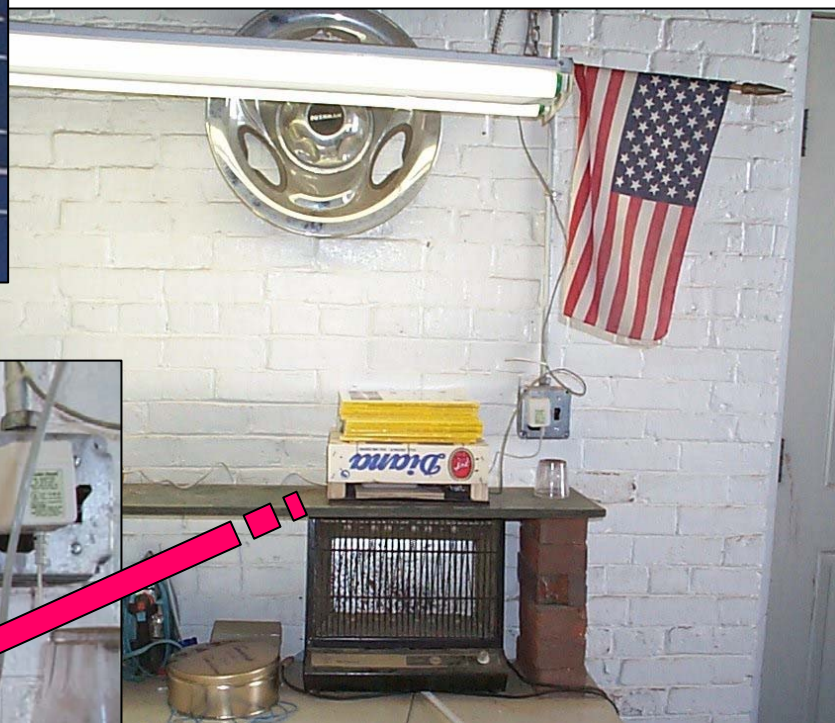
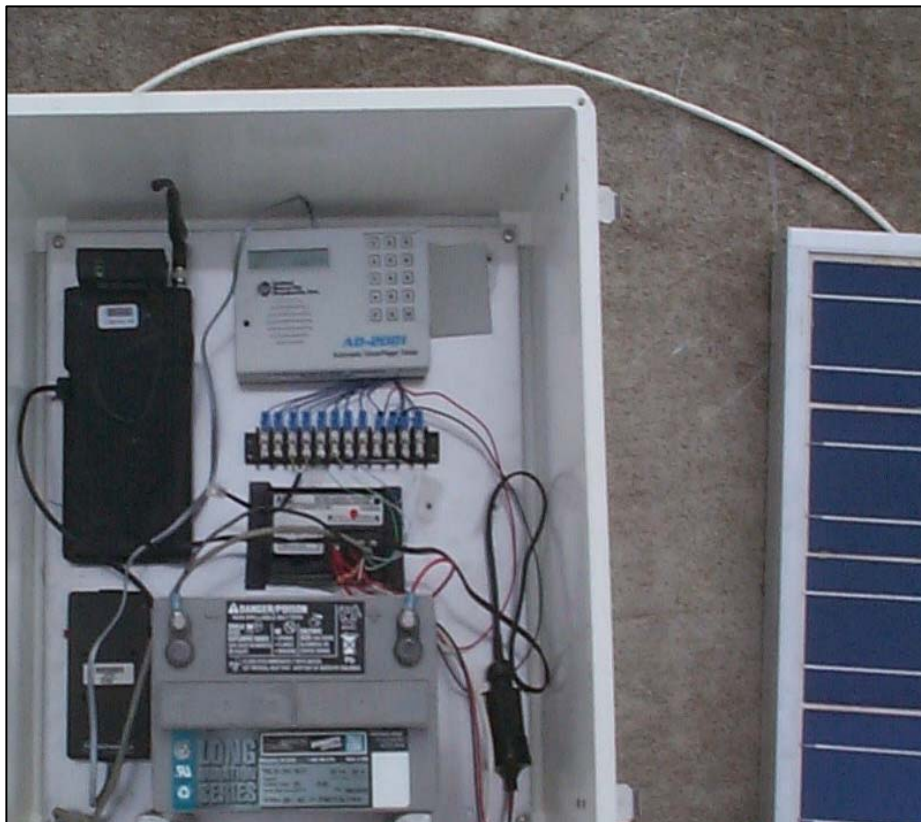
# Early Warning

- Provides critical information
- Two weeks to six months lead time
- Inexpensive and invaluable
  - Trained observers
    - Part of emergency response team
    - Track pre-event ice conditions and during event
    - Helpful for after-action assessment
  - Ice motion detectors
    - Trip wires in ice
      - Alarms inform emergency managers
      - Select locations to give days/hours warning
      - Can be remote
  - Automated stage alarms
    - Useful for open-water events also
    - Remote packages available
  - Web cameras



← To Ice Motion Detector







Stage Detectors/Alert Systems



**USACE Engineer Research and Development Center**  
Cold Regions Research and Engineering Laboratory



## Web Camera Images at ERDC/CRREL Real-time Data from the Israel River, Lancaster NH

[Latest Information](#) and [Recent images from active cameras](#)

The water temperature and stage in the Israel River at Lancaster NH are being monitored as part of a test of an early warning flood system for use in ice-affected rivers. The plots shown below are from the site and should automatically update every 2 hours. We are also testing a new web camera system and transmission modes. The camera images below are hourly images. For further information, please contact Dr. Kate White at

[Kathleen.D.White@erdc.usace.army.mil](mailto:Kathleen.D.White@erdc.usace.army.mil)

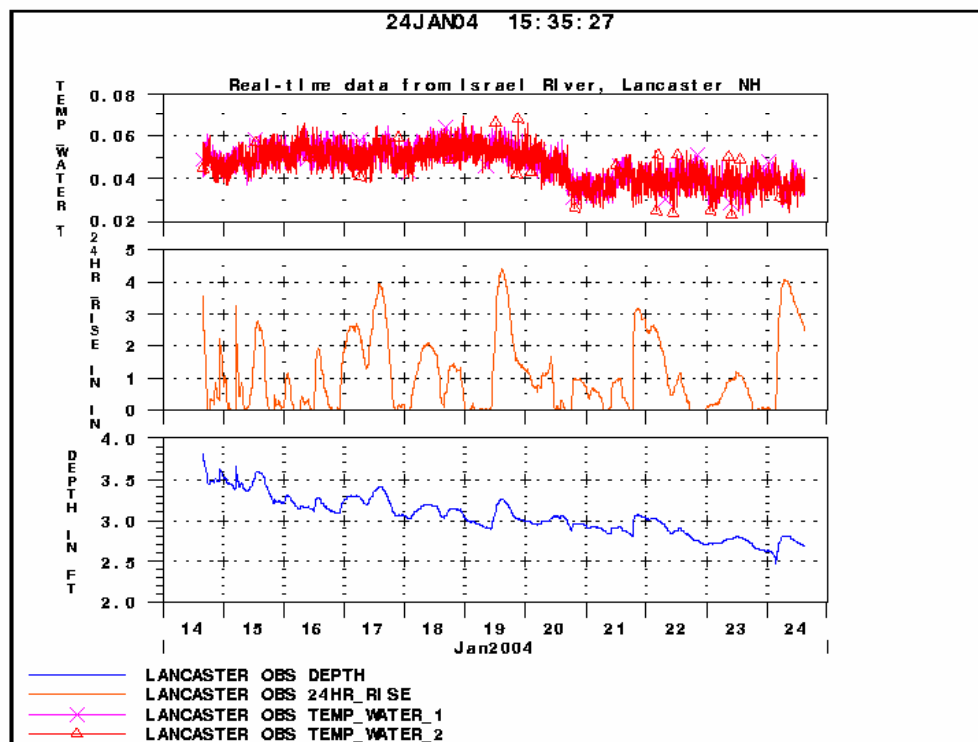




Image from Camera 1 [Table of images from above camera](#) or [Animation of images](#)



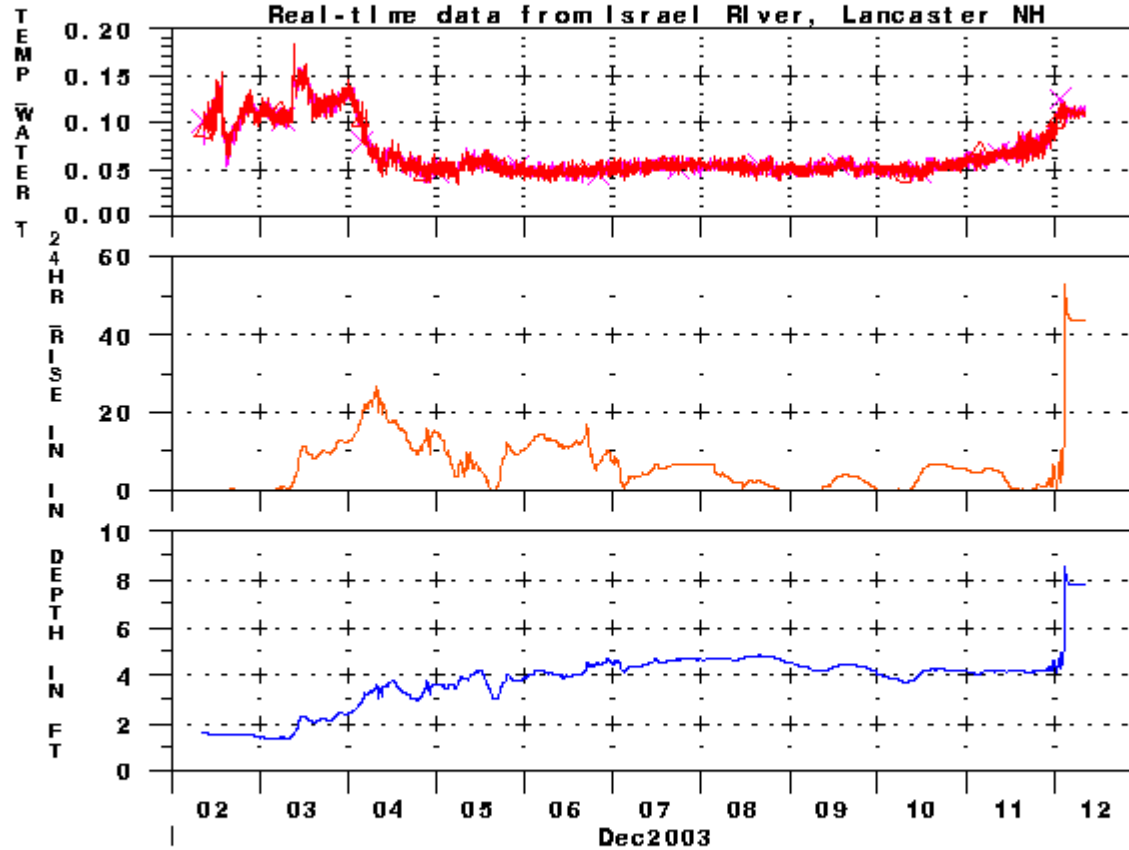
Image from Camera 2 [Table of images from above camera](#) or [Animation of images](#)



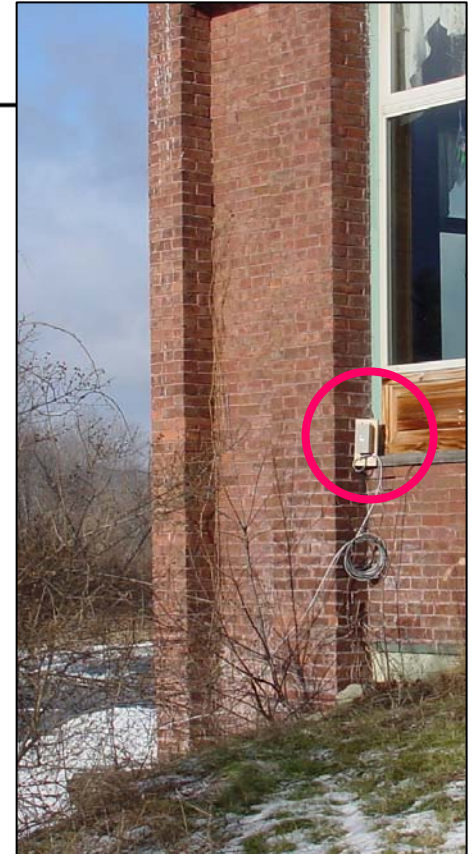
Image from Camera 3 [Table of images from above camera](#) or [Animation of images](#)

12DEC03 08:35:22

Real-time data from Israel River, Lancaster NH



— LANCASTER OBS DEPTH  
— LANCASTER OBS 24HR\_RISE  
—x— LANCASTER OBS TEMP\_WATER\_1  
—△— LANCASTER OBS TEMP\_WATER\_2



Real-time White River Junction VT Camera - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address <https://webcam.crrel.usace.army.mil/whiteriver/>

**USACE Engineer Research and Development Center**  
Cold Regions Research and Engineering Laboratory

**Web Camera Images at ERDC/CRREL** Real-time White River Junction VT Camera

[Latest Information](#) and [Recent images from active cameras](#)





[Table of images from above camera](#) or [Animation of images](#)

Real-time data for USGS 01049320 Kennebec River at Fr. Curran Bridge at Augusta, ME - Microsoft

File Edit View Favorites Tools Help

Address [http://waterdata.usgs.gov/me/rwis/uv/?site\\_no=010493](http://waterdata.usgs.gov/me/rwis/uv/?site_no=010493)

**USGS**

[Water Resources](#)


**USGS 01049320 Kennebec River at Fr. Curran Bridge at Augusta, ME**

**PROVISIONAL DATA SUBJECT TO REVISION**

Available data for this site

Station operated in cooperation with the [Maine River Flow Advisory Commission](#).

USGS Fri Jan 23 13:09:17 2004



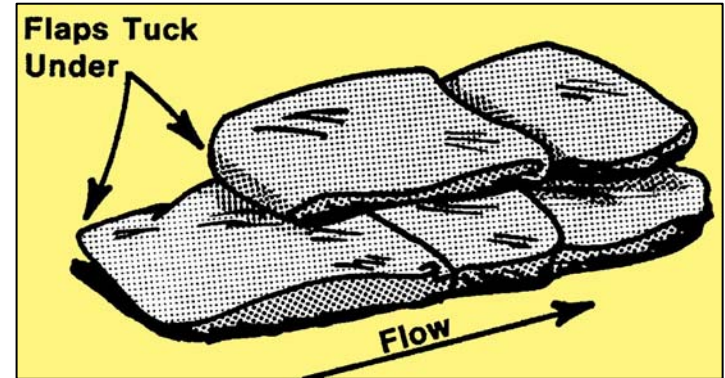
**USGS**  
science for a changing world

Press the 'Reload' or 'Refresh' button on your browser to view the most recent image.  
(NOTE: Image time stamp should be within 20 minutes of the current time.)

| Available Parameters                    | Output format                      | Days                           |   |
|---|------------------------------------|--------------------------------|---|
| All 1 parameters available at this site | <input type="text" value="Graph"/> | <input type="text" value="7"/> | <input type="button" value="get data"/> |
| 00065 Gage height (DD 01)               |                                    | (1-31)                         |   |

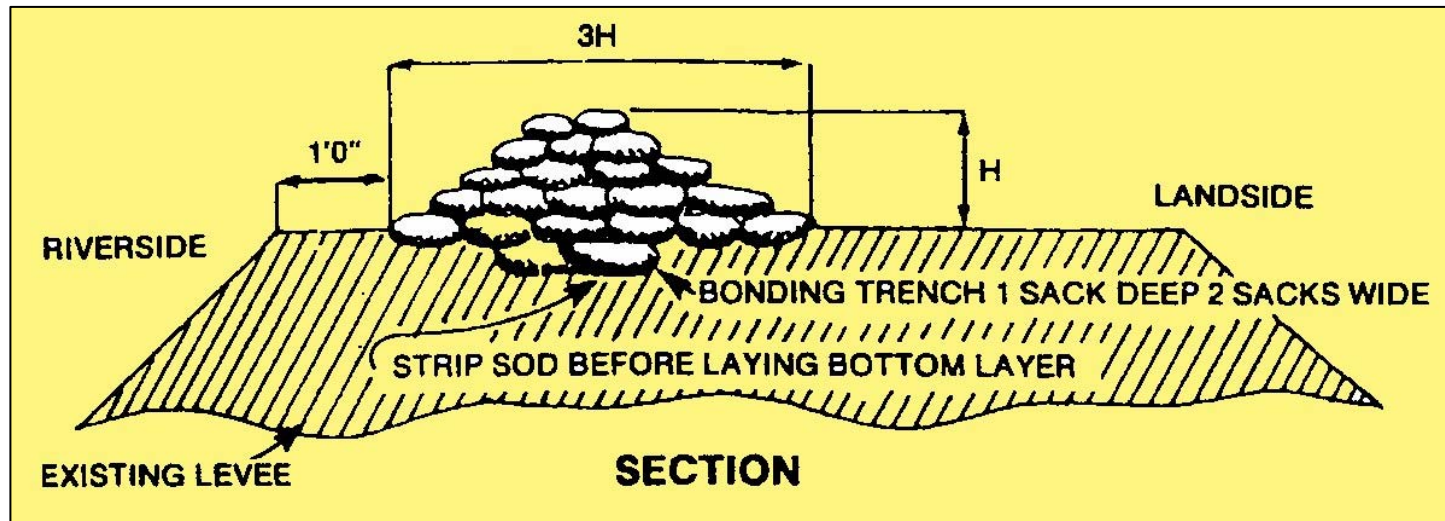
# Sand Bagging Review

- Use bags about 14-18" wide, and 30-36" deep
- Materials:
  - Burlap sacks
    - Empty bags can be stockpiled for emergency use
    - Will be serviceable for several years if properly stored
    - Filled bags of earth material will deteriorate quickly
  - Polypropylene
    - Can be stored for a long time with minimum care
    - Not biodegradable, must have disposal plan
  - Garbage bags are too slick to stack
  - Feed sacks are too large to handle
- Fill between one-third ( $1/3$ ) to one-half ( $1/2$ ) of bag capacity
- Prefer heavy bodied or sandy soil; gravels and larger usually too permeable
- Fold the open end of the unfilled portion of the bag to form a triangle
  - Can tie, but this takes time and is not more effective; if tied bags are used, flatten or flare the tied end
- Place lengthwise and parallel to the direction of flow, with the open end facing against the water flow
  - Tuck the flaps under, keeping the unfilled portion under the weight of the sack
  - Offset bags by  $1/2$  the filled length of the adjoining bag
  - Stamp into place to eliminate voids, and form a tight seal
- Stagger the joints when multiple layers are necessary
- For unsupported layers over 3 layers high, use the pyramid placement method



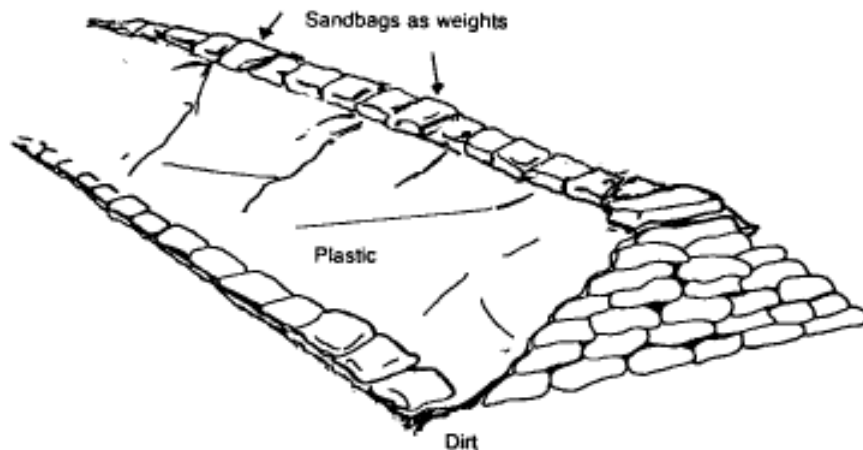
# Sand Bagging Review

- Pyramid Placement (> 3 high)
  - Place the sand bags to form a pyramid by alternating header courses (bags placed crosswise) and stretcher courses (bags placed lengthwise)
  - Stamp each bag in place
  - Overlap sacks
  - Maintain staggered joint placement
  - Tuck in any loose ends
- Quantity of sand bags for 100 linear feet of dike is estimated as:
  - 800 bags for 1-foot-high dike
  - 2,000 bags for 2-foot-high dike
  - 3,400 bags for 3- foot-high dike



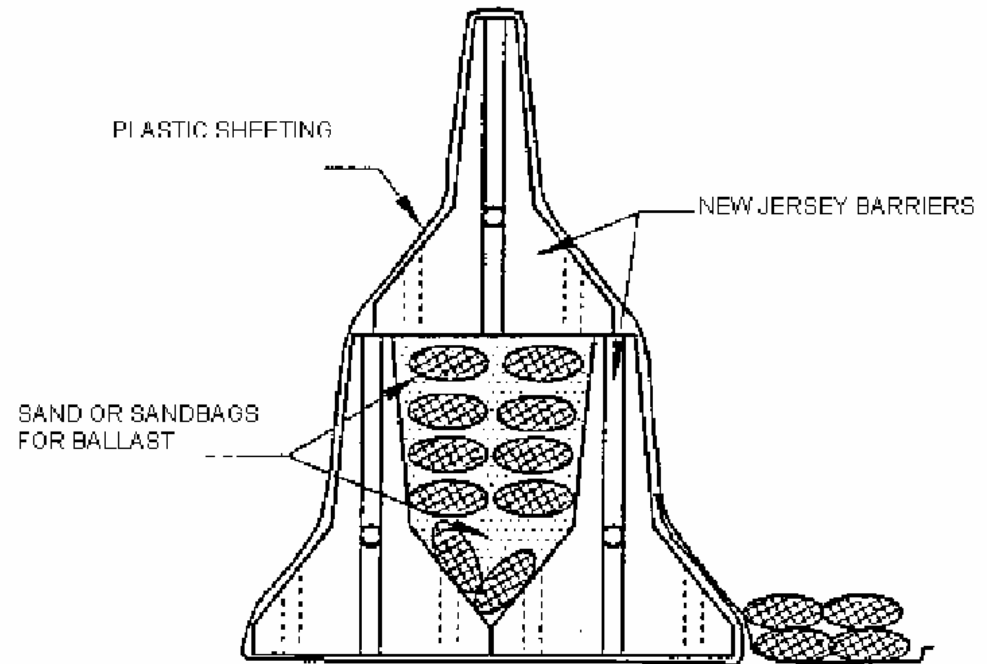
# Sand Bagging Review

- Polyethylene sheeting
  - Will improve the performance of any sand bag barrier
  - > 6 mils thick
  - 3 times as wide as the intended height of the sand bag barrier
  - Don't stretch tightly
  - Stair step up or cover bags as shown below
  - Seal with sand bags at base of levee and at crown



# Jersey Barriers

- Double row with staggered joints preferred to single row
- Fill between with sand, sandbags
- If permeable material used to fill, wrap with plastic sheeting
- May be stacked but single height preferable for stability



# Diversion Channels



Can use snow, snow with sheeting, sand/gravel/rock alone or with sheeting, sandbags, jersey barriers....

# Ice Weakening

- Mechanical: Immediate strength reduction
  - Ice cutting
    - 4WD trencher
    - Ditch Witch
  - Ice breaking
    - Amphibious excavator
    - Vessels
- Thermal: Accelerate natural ice deterioration
  - Hole drilling
  - Dusting
  - Flow effects



# Aerial Dusting

- Sand or other dark material increases solar absorption and enhances ice deterioration
- High sun angle and longer hours of sunlight required for optimum results (i.e., after mid-February)
- Difficult to assess effectiveness
- Potential environmental issues
  - Permitting often required



# Hole Drilling

- Oconto River, WI
  - 10 ft grid, central 2/3 of channel
  - Holes expand to weaken sheet
  - Weakens ice in jam location to increase conveyance, transport capacity of channel



# Effect of Flow on Thinning of Jam

- Jam thinning or melting can be significant if incoming water temperature is above freezing
- Observations indicate that almost all available heat is transferred to ice melting within the upper 1 mile of jam
- As jam shortens or preferential flow paths develop, jam failure may occur
- Very rough rule of thumb per  $\Delta^\circ \text{F}$ :  $\dot{V}_m (\text{cfs}) = 0.01Q (\text{cfs})$

**Table 5. Measurements of water temperature entering breakup ice jams. The heat-transfer length is the distance from the head of a jam to the point where the water has lost > 90% of its sensible heat.**

| <i>Reference</i>        | <i>River</i>   | <i>Entering water temp., <math>\Delta T</math> (<math>^\circ\text{F}-32</math>)</i> | <i>Heat-transfer length (miles)</i> | <i>Comments</i>   |
|-------------------------|----------------|---|-------------------------------------|---|
| Calkins (1984)          | Ottaquechee R. | 1.3   | 0.8                                 | Upstream of refrozen jam, time between breakup and measurement unknown. |
| Prowse and Marsh (1989) | Liard R.       | 3.1   | 2                                   | Measured during breakup event.  |
| Beltaos et al. (1998)   | Matapedia R.   | 4.5   | 0.2                                 | Time between breakup and measurement unknown.                           |

# Effect of Flow on Thinning of Jam

- Example (remember, this is very rough!):
- Assume incoming water temperature is 32.4 °F, Q=20,000 cfs
- Estimated ice jam volume:  
Ice Volume = avg. length x avg. width x avg. thickness x (1 - ice jam porosity)  
= 1 mile x 400 ft x 10 ft x (1- 40%)  
= 12 million ft<sup>3</sup>
- Estimated melt rate :  
Melt rate = 1% x avg. river discharge in cfs x water temp in deg F above 32. °F  
= 1% x 25,000 cfs x 0.4 °F  
= 100 cubic feet of ice melted per second
- Time required to melt out jam = ice volume in jam / melt rate  
= 12 million ft<sup>3</sup> / 100 cfs = 120,000 sec = 33 hours

# Emergency Measures

- Jam in place
- Cost & effectiveness depend on timing
  - Try to minimize damages
  - Time is critical
- Excavation
- Blasting: if state approved plan in place already
- Flood Fighting
- Do nothing (estimate melt rate)
- Lead time = effectiveness

# Excavation

- Most efficient when stage rising
- Potential safety issues
- Potential environmental issues
- Pre-positioned equipment helpful
  - excavator, clam-shell, bulldozer
  - clear channel D/S of toe
  - dislodge key pieces at toe
- Expensive to excavate ice pieces after stage falls
- Can be combined with blasting  
(excavate where safe, blast upstream end of jam)





# Excavation Examples

- Gorham, NH



- Morrisonville,  
NY

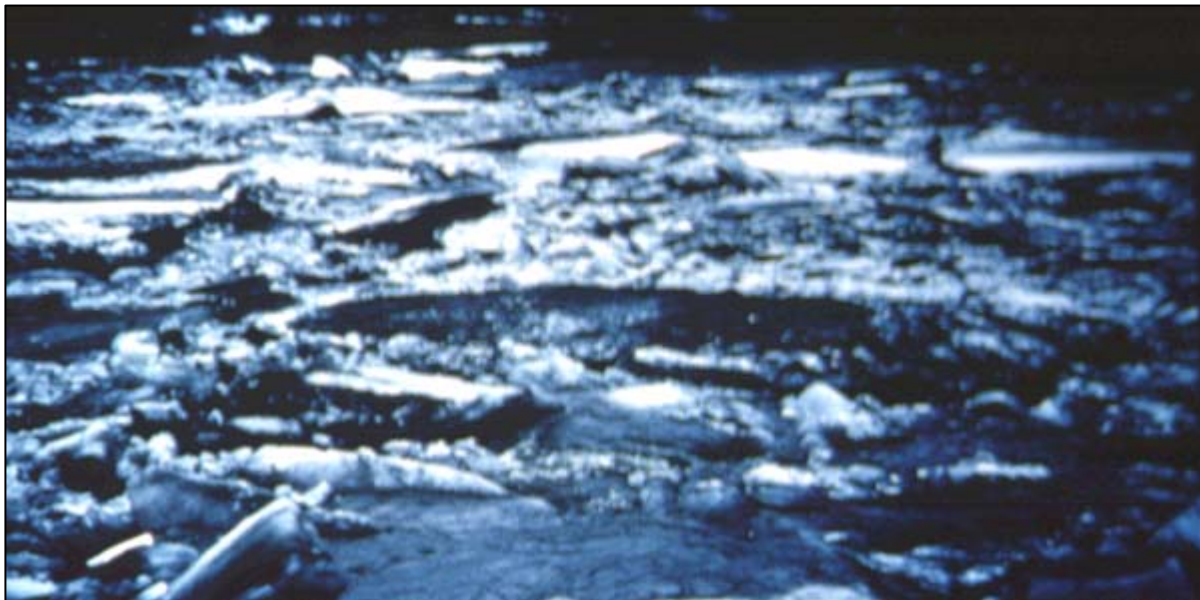
# Blasting

- Requires open water downstream
- Work from downstream to upstream
- Charges should be placed just under ice
- Pre-planning needed (liability issues, rapid response)
- Not suitable for urban area



# Do Nothing

- Estimate melt rate
- Thin, weak ice
- Little remaining ice supply
- Continued mild temperatures
- Late season jam (check records)
- Other constraints



# Permanent Measures

- Structural solutions
  - Ice control structures (ICS's)
  - Diversion channels
  - Flow control
  - Thermal discharge
  - Levees, floodwalls
  - Flood proofing
  - Land management
- 2-5 year lead time
- Expect high benefits and reliability
- Generally costly although some low-cost solutions are under development

# Ice Control Structure, Lamoille River, Hardwick, VT

